United States
Department of
Agriculture

Soil
Conservation
Service

Cooperating
Agencies

FLOOD PLAIN MANAGEMENT

A Study of Linville Creek, Rockingham County, Virginia

July 1982

FOREWORD

The Soil Conservation Service, U. S. Department of Agriculture, prepared the information in this flood plain management report. The Virginia State Water Control Board, the Shenandoah Valley Soil and Water Conservation District, and Rockingham County cooperated in the report. Rockingham County also paid the printing and finishing costs for the report.

The flood hazard and land use information should serve as a technical base for flood plain management programs. State and local government, as well as the public, will benefit from increased knowledge of flood hazards on Linville Creek. A program to minimize future flood damages can be developed from this information.

Describing the legal aspects and methods of conducting management programs is not within the scope of this report. However, some general recommendations are included.

We thank the many people who contributed information for the study. We also thank the landowners who gave permission for field surveys and photographs of their land.

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FLOOD PLAIN MANAGEMENT STUDY
Linville Creek
Rockingham County, Virginia

INTRODUCTION

The purpose of flood plain management is to define the flood plain and identify potential flood losses. Local officials will use this report as a guide in developing a flood plain management program for Linville Creek. Regulation of flood plain land use can minimize loss of life and property damage from future floods. Section 872.0 of the Virginia Uniform Statewide Building Code (Reference 1) sets certain requirements for flood plain management. This study complies with those requirements.

Involved Organizations and Responsibilities

The Shenandoah Valley Soil and Water Conservation District (District) and the Rockingham County Board of Supervisors (County) applied for a flood plain management study of Linville Creek. The State Water Control Board (Board) received the application and requested the Soil Conservation Service (SCS) to conduct this study. SCS prepared a plan of study describing the study area, location, scope, responsibilities, estimated costs, funding arrangements, and tentative schedules. This plan of study was reviewed by the District, County and Board and approved on March 27, 1979.

SCS had responsibility for implementing the technical phases of the study, preparing maps and drawings and printing portions of the report. The County provided available information on the study area and obtained permission for field surveys. The County also paid all expenses in connection with printing and finishing. The County and District will hold public meetings and provide necessary publicity to implement a flood plain management program. The Board and SCS will provide assistance to assure prompt and effective use of the study findings.

Authorities

The Soil Conservation Service (SCS) of the U. S. Department of Agriculture participated in this study under the following authorities:

Section 6, Public Law 83-566, as amended.
Federal level Recommendation 3, A Unified National Program for Flood Plain Management, Water Resources Council, September 1979
Executive Order 11988, January 25, 1978
U. S. Department of Agriculture Secretary's Memorandum 1606 and 1607; November 7, 1966

State statutes and directives of the Governor of Virginia authorize Board, District, and County involvement in flood plain management surveys and related studies. This study was performed in accordance with a Joint Coordination Agreement for Flood Plain Management between the State Water Control Board and the Soil Conservation Service, dated January 1979.

DESCRIPTION OF STUDY AREA

Upstream Drainage Area

The Linville Creek drainage area comprises 48 square miles above its junction with the North Fork Shenandoah River and above the town of Broadway, Virginia (figure 1). The Shenandoah is a subbasin of the Potomac River which is in the Mid-Atlantic Region as designated by the Water Resources Council. The USGS Hydrologic Unit code number in the area is 02070006.

The watershed is in the Northern Appalachian Ridges and Valleys physiographic province. Soils are formed primarily in residium from limestone, sandstone and shale. Chilhowie-Edom is the predominant soil series. [1/] Land use is about 75 percent pasture, 15 percent hay, 8 percent cropland and 2 percent woodland and miscellaneous. No published soil survey is available at this time.

Normal annual precipitation is 35 inches, including 25 inches of snowfall which equals about two inches of rainfall. Average January temperature is 33 degrees F and the average for July is 74 degrees F. Average growing season is 170 days.

Flood Plain

Virginia primary highway 42 parallels Linville Creek through the study area. Several secondary roads cross the flood plain. Except for about a dozen farmsteads and rural residential lots, the flood plain is used mostly for pasture and hay. Flooding is the principal limitation on more intensive use of the flood plain soils.

A total of 13.6 stream miles were studied. This included 10.6 miles of Linville Creek from Broadway up to the vicinity of State Route 42 above Edom; 1.2 miles of the West Fork Tributary up to 1000 feet above State Route 778; and 1.8 miles of Joes Creek up to the second crossing of State Route 780.

Natural and Beneficial Values

Linville Creek is classified as a mountainous zone stream characterized by narrow flood plains, steep slopes and rapid runoff of floodwaters. The study area has no unusual natural values. The stream corridor does have moderate potential for development as non-game fish and wildlife habitat and limited potential for game species.

[1/] Soils data is available at the SCS Rockingham County Field Office, Virginia


VIRGINIA
UPPER LIMIT OF STUDY
UPPER LIMIT OF STUDY
UPPER LIMIT OF STUDY
JOES CREEK
WEST FORK
LINVILLE
LINVILLE
LINVILLE
CREEK
STATE ROUTE 42
BROADWAY
SHENANDOAH RIVER
SOUTHERN
HARRISONBURG
ROCKINGHAM COUNTY
U.S. ROUTE 11
INTERSTATE 81
STATE ROUTE 259
Legend
Study Stream
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FLOOD PLAIN
MANAGEMENT STUDY AREA
VICINITY MAP
LINVILLE CREEK
ROCKINGHAM COUNTY
VIRGINIA
SCALE 1:50,000
MILE
KILOMETER
March 1980
Base Source U.S.G.S. 7.5 minute Topo Quads from 1967 to 1968

Figure 1

Extensive use of the flood plains for pasture has resulted in destruction of much of the riparian vegetation. Protection of stream banks by fencing and replanting are the primary needs to restore the potential to provide food and cover for aquatic life and small animals.

The stone bridge (built about 1895) over Linville Creek at Edom is listed in the National Register of Historic Properties. The bridge could be damaged during extreme floods.

FLOOD HISTORY

Flooding on Linville Creek and its tributaries usually results from intense thunderstorm activity. Excess rainfall concentrates quickly on the steep slopes; flood stages rise rapidly and fall just as quickly. At three to five year intervals moderate damage accrues to bridges and road fills, agricultural land and facilities.

Larger, less frequent floods cause similar but greater damage and the more extreme storms are a hazard to life. The larger floods would cause damage to farm homes and rural residences on the higher elevations of the flood plains. Average annual flood damages are estimated at $35,000 to $40,000 at 1979 values.

FLOOD POTENTIAL

Present Conditions

Large Floods. Extreme floods would inundate about 600 acres of primarily agricultural land (see table below). Extensive damage would be done to the land, crops, fences, farm roads, buildings and machinery. Damage to dwellings and businesses would occur mostly along the main stem of Linville Creek. Velocities would average about five feet per second and exceed seven feet per second in some reaches. Out-of-bank stages would range from about two to ten feet. Duration of flooding would seldom exceed six hours except during storms of intense and prolonged rainfall.

Flood Hazard Areas. The acres tabulated below are used primarily for pasture and other agricultural uses. Only about two percent is devoted to roads, farmsteads and similar uses.

	Acres by Flood Frequency		Buildings in 100-year flood plain		
Stream	100-year	500-year	Dwellings	Commercial	Other
Linville Creek	430	450	10	4	2
West Fork	51	55	2	1	1
Joes Creek	36	41	1	1	3
TOTALS	517	546	13	6	6

Figure 2. Potential flood stages at State Route 809 crossing of Linville Creek, looking downstream (north).

Figure 3. Potential flood stages at State Route 721 crossing of Linville Creek, looking downstream (north).

Flood Hazard Exhibits. The technical data needed for establishing a flood plain management program is in the appendix. Also the appendix outlines a procedure for determining the flood elevations at any particular location.

Flood hazard photomaps show the area covered by the 100 and 500-year floods. Where only one line is shown, there is no difference in the boundaries of the two flood areas. These photomaps should only be used to determine approximate flood elevations.

Flood profile plates provide elevations of the 10, 50, 100 and 500-year floods at any location along the length of the streams. The elevations and discharges of the 10, 25, 50, 100 and 500-year flood at each surveyed cross section are given in Table A-1. Sample cross sections illustrate how the flood areas were located on the photomaps.

Also included in the appendix is a list of benchmark elevations and locations, a glossary of terms and a list of references. The basic data is on file in the office of the USDA, Soil Conservation Service, 400 North Eighth Street, P. O. Box 10026, Richmond, Virginia 23240.

Limitations on Use of Data. The flood elevations given in this report should be considered as minimum elevations. During floods, uprooted trees and other debris may collect on bridges and culverts and clog the channels. Such obstructions increase the depth and extent of flooding. Analyses were made without showing the effects of potential obstructions. Also, extremely rare events such as climatic changes were not analyzed.

Future Conditions

The hydrologic conditions in the upstream areas are expected to improve as farmers and foresters continue to apply good management and conservation practices. This improvement is expected to reduce runoff approximately to the extent that additional development will increase runoff. Therefore, the flood hazard and damage potential is not expected to change significantly in the next 10 to 15 years.

FLOOD PLAIN MANAGEMENT

Existing Programs

Rockingham County has previously enacted the usual ordinances relating to zoning, subdivisions, sanitation utilities and similar developments. None of the ordinances provide specifically for regulation in the use and management of flood prone areas, but recent state legislation requires adoption of such regulations by localities. Also, a commitment to such constraints are now a prerequisite for federal funding under certain national programs.

Adopted in 1977, an amendment to the Virginia Statewide Building Code (reference 1) requires restrictions on new construction and flood proofing of existing structures below the 100-year flood elevation. Data in this report can be used to comply with this amendment. The bibliography lists several references (4-7) that discuss flood plain regulation and flood proofing measures.

The Virginia Erosion and Sediment Control Handbook (reference 2) was adopted in 1974. The handbook includes mandatory criteria for control of runoff and sediment, and for prompt revegetation of sites disturbed by earth-moving operations in urban areas.

Rockingham County has participated in the national flood insurance program since 1974 under the emergency program. Participating communities are required to regulate use and development of flood plains. The program is administered by the Federal Emergency Management Agency (FEMA). In those communities participating in the FEMA program, owners and occupiers of all buildings and mobile homes in the community are eligible to obtain sub-sidized flood insurance coverage.

Floodways

Any construction activity that raises the elevation of the flood plain will restrict flow and increase flood heights. One part of flood plain management is balancing the benefits of flood plain development with the increased flood hazard. The floodway concept divides the 100-year flood area into a floodway and a floodway fringe. The floodway fringe is the portion of the flood plain that can be completely obstructed without increasing the water surface elevation of the 100-year flood more than 1 foot or creating hazardous depths or velocities in the floodway. The floodway is the remaining portion of the channel and the flood plain (Figure 4).

On Linville Creek, the computed floodway data exceed the criteria for hazardous conditions 1/ at all surveyed cross sections. This indicates that a continuous floodway through the study area will not be practical. If these theoretical computations are to be used as a basis for further study of selected segments, the data will be available in SCS files with other basic data.

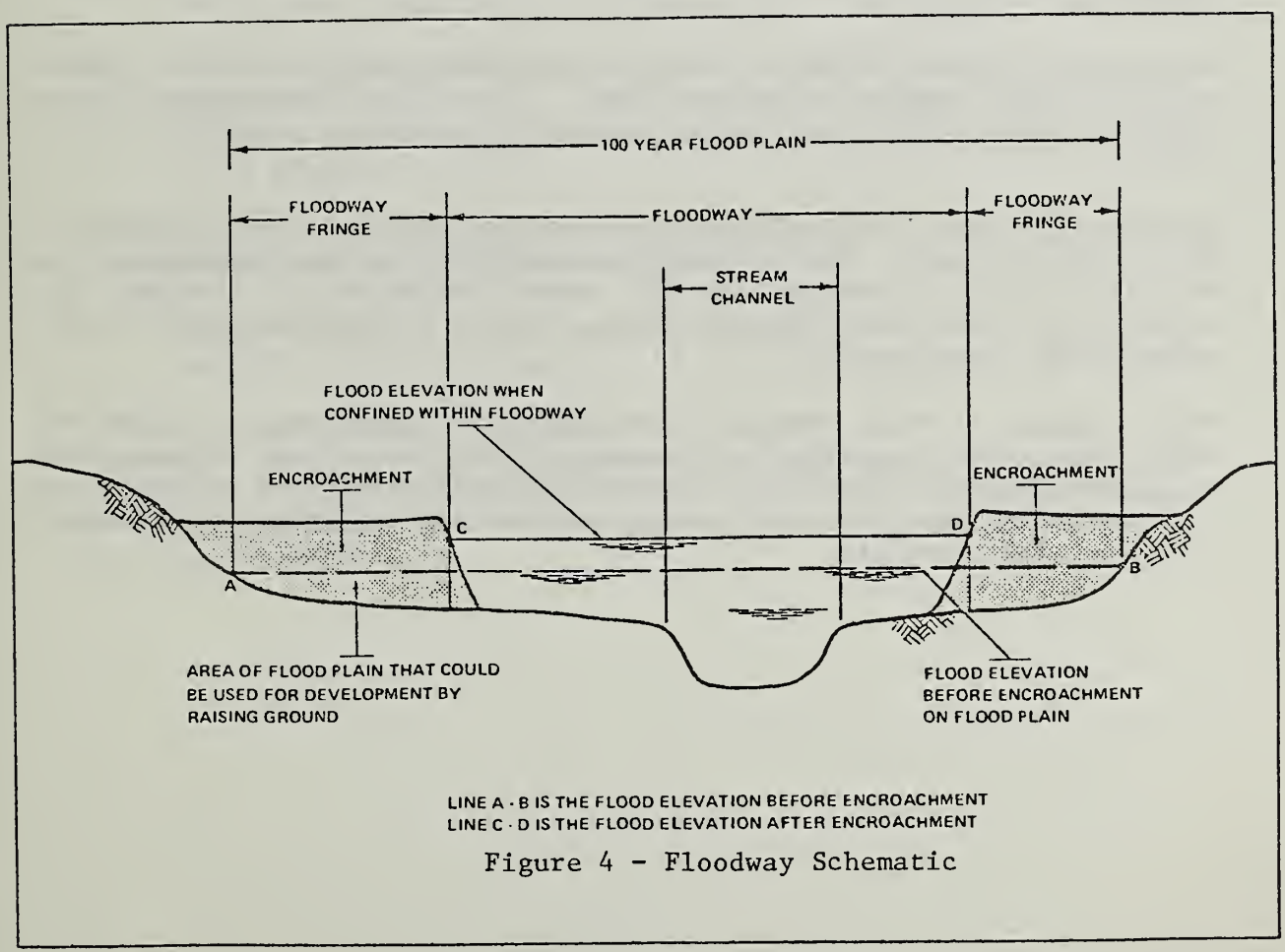


Figure 4 - Floodway Schematic

1/ A hazardous condition is considered to exist if: the depth in feet times the velocity in feet per second exceeds seven; or the depth exceeds three feet; or the velocity exceeds 12 feet per second.

Recommendations

The local sponsors will use the report and other such studies in the county to develop and implement a comprehensive flood plain management program. It is specificly recommended that the sponsors:

--review and update local ordinances relating to flood plains as a sound basis for the program; in particular, include restrictions on use and occupancy of flood plains;
--carry out public information activities stressing the need for and the community benefits of the program;
--continue to emphasize the importance of proper land use and conservation treatment in reducing flood hazards;
--encourage owners and occupants of buildings and mobile homes within and adjacent to the delineated flood hazard areas to carry flood insurance on the structures and contents; and
--determine what assistance is available and implement the restoration of riparian vegetation along the study streams.

Evaluation of Potential

The recommendations above indicate the potential opportunities to reduce or minimize the impacts of future floods. The primary opportunities have to do with avoiding or regulating occupancy or modification of the flood plains.

The two state laws previously mentioned provide useful tools to implement these opportunities. One prohibits or restricts further development in the flood plain (reference 1); the other (reference 2) provides for control of runoff and sediment from upstream development which might increase the flood hazard.

Public support can be enhanced through public information activities which stress the specific and community benefits of the flood plain management program. This will also afford the opportunity to emphasize the continuing importance of proper land use and conservation treatment throughout the community.

APPENDIX

This appendix provides the data needed to use this report. It is suggested that the reader review the section on Use of Technical Data and Related Materials in the main body of this report.

The Flood Hazard Area Photomaps can be used for decisions where precise elevations are not required; for example, a brief check of the appropriate photomap may indicate that a proposed building site is obviously in or out of the flood plain.

Following the photomaps are flood profiles and benchmark data. These two exhibits can be used with the photomaps to determine flood elevations at any point along the streams in the study area as follows:

1. On the appropriate photomap find the point on the stream where the flood line is to be located; then scale the distance along the stream to the nearest cross section.

2. On the appropriate flood profile sheet, scale the distance determined in Step 1 from the cross section back to the original stream location, and read the elevation of the desired flood frequency line.

3. Transfer the elevation determined in Step 2 to the ground from the nearest established benchmark.

   If the point on the ground is at one of the surveyed cross sections, the elevation can be read directly from Table A-1.

Typical cross sections following the profile plates illustrate the procedure used for placing flood elevations on Flood Hazard Area Photomaps. The photomaps are based on semicontrolled aerial mosaics and the dimensions of the photomaps are not identical to those on the cross sections.


38°30'00"
38°32'30"
38°35'00"
38°37'30"
VIRGINIA
78°57'30"
78°47'30"
78°52'30"
UPPER LIMIT OF STUDY
UPPER LIMIT OF STUDY
UPPER LIMIT OF STUDY
1
2
3
4
5
LINVILLE
LINVILLE
CREEK
LINVILLE
CREEK
EDOM
ROUTE
42
SOUTHERN
SOUTHERN
SOUTHERN
LINVILLE
HARRISONBURG
U.S. ROUTE 11
INTERSTATE 81
STATE
38°28'30"
38°30'00"
38°32'30"
38°35'00"
Legend
Study Stream
Sheet Coverage
U.S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FLOOD PLAIN
MANAGEMENT STUDY AREA
AND MOSAIC SHEET INDEX
LINVILLE CREEK
ROCKINGHAM COUNTY
VIRGINIA
SCALE 1:50,000
1 ½ 0 1 MILE
1 .5 0 1 KILOMETER
March 1980
Base Source U.S.G.S. 7.5 minute Topo Quads from 1967 to 1968
LIB NO 1-13566 2

SOURCE Semi-controlled mosaic prepared from USDA-ASCS AERIAL photography flown 1974

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD PLAIN MANAGEMENT STUDY
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

AUGUST 1981 — SHEET 2 OF 5

LEGEND

- Stream channel
- 500 year flood area
- 100 year flood area
- 9 — Stream miles
- 8 — Surveyed valley sections
- × BM 3 — Bench mark

SOURCE Semi-controlled mosaic prepared from USDA-ASCS AERIAL photography flown 1974

SCALE 1:5200

500 0 500 1000 1500 FEET

100 0 100 200 300 400 500 METERS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD PLAIN MANAGEMENT STUDY
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

AUGUST 1981

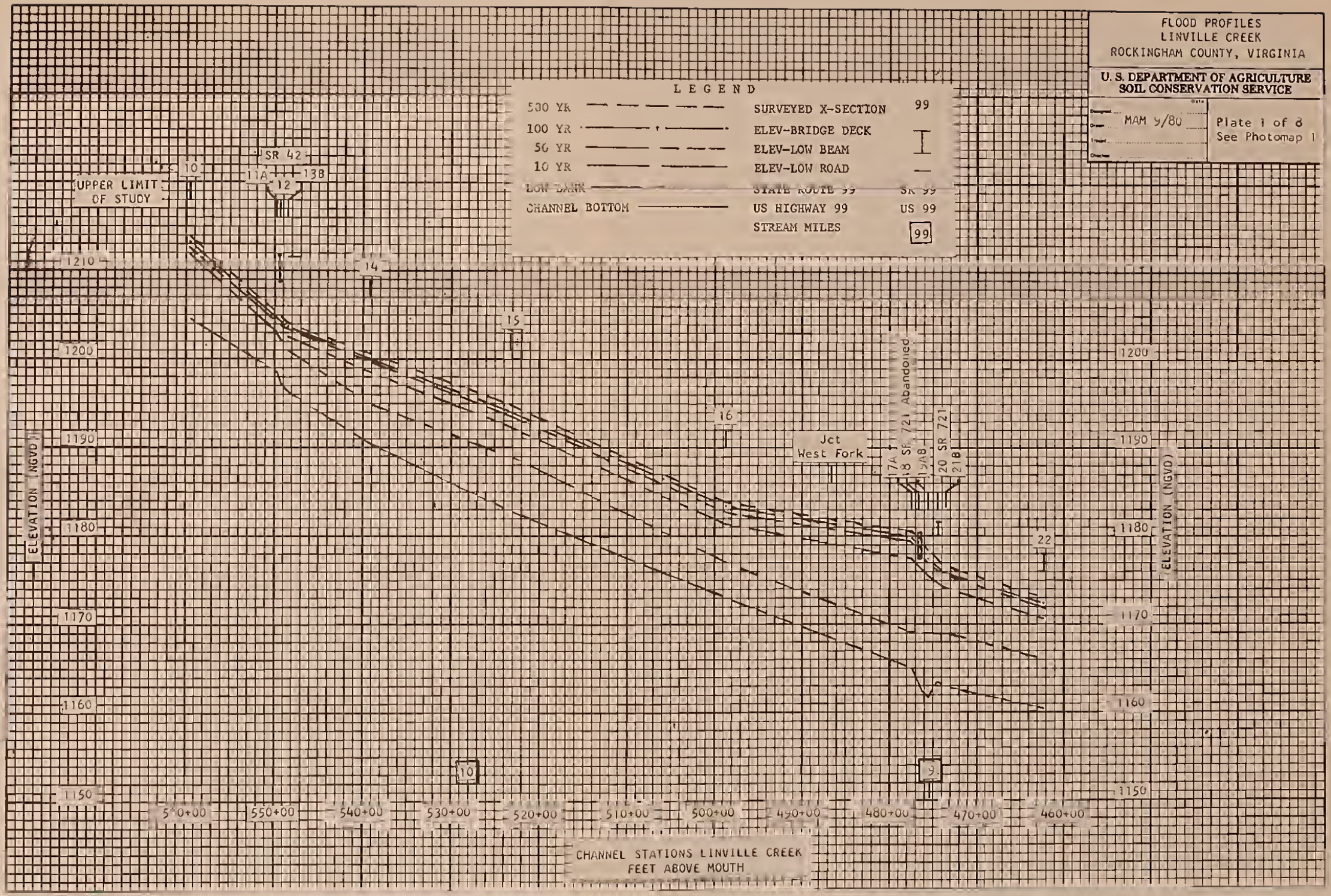
SHEET 3 OF 5


MATCH PHOTOMAP 3
43A
45B
BM 61
46
47
48
STATE ROUTE 784
5
4
49
50A
52B
BM 16A
STATE ROUTE 809
53
MATCH PHOTOMAP 5
3
STATE ROUTE 42
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
FLOOD PLAIN MANGEMENT STUDY
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA
AUGUST 1981
SHEET 4 OF 5
LEGEND
Stream channel
500 year flood area
100 year flood area
9 Stream miles
8 Surveyed valley sections
× BM 3 Bench mark
SOURCE Semi-controlled mosaic prepared from USDA-ASCS AERIAL photography flown 1974
SCALE 1:7200
500 0 500 1000 1500 FEET
100 0 100 200 300 400 500 METERS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

FLOOD PLAIN MANAGEMENT STUDY
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

AUGUST 1981 SHEET 5 OF 5

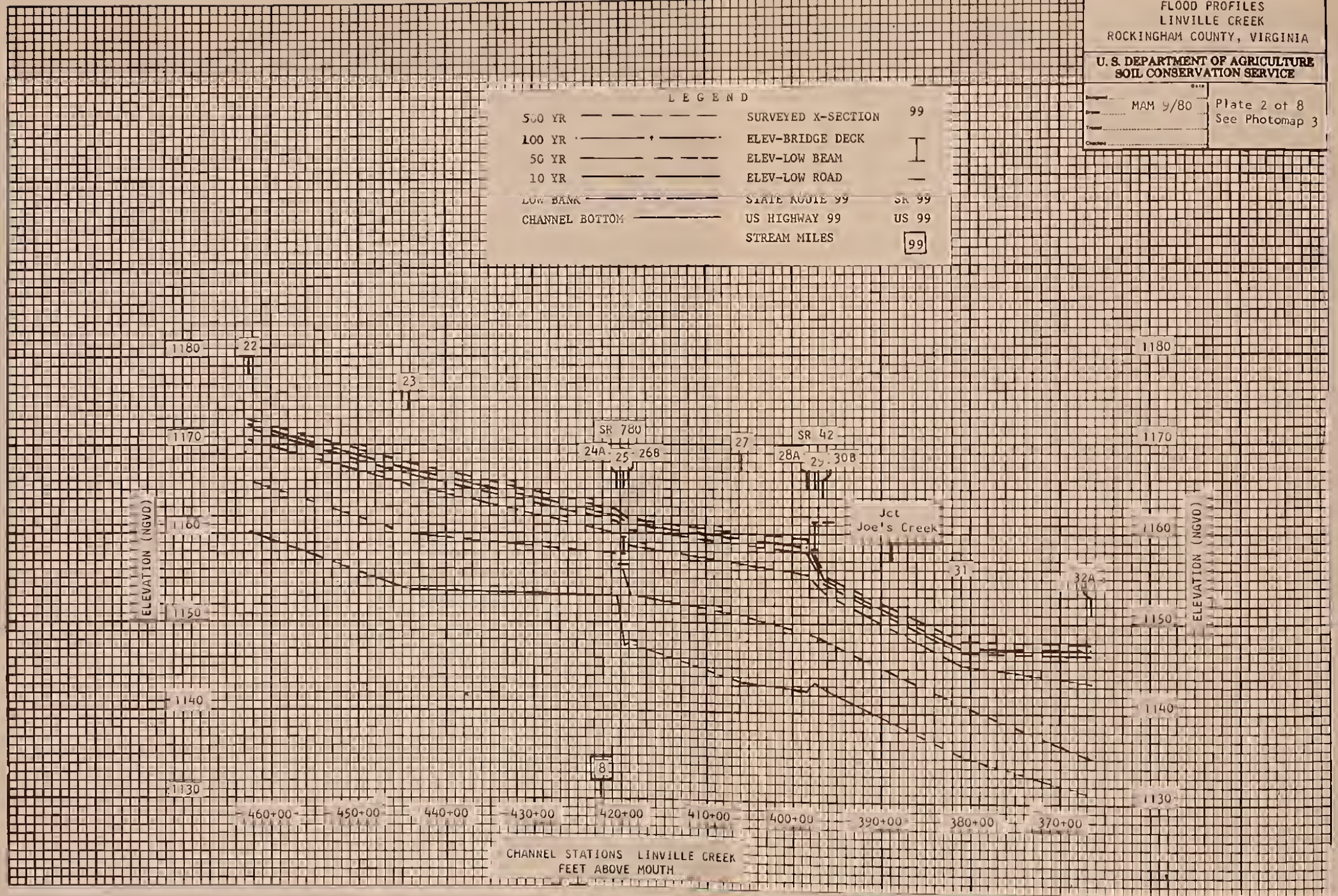

FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MAM 9/80
Plate 1 of 8
See Photomap 1
LEGEND
500 YR
100 YR
50 YR
10 YR
LOW BANK
CHANNEL BOTTOM
SURVEYED X-SECTION
ELEV-BRIDGE DECK
ELEV-LOW BEAM
ELEV-LOW ROAD
STATE ROUTE 99
US HIGHWAY 99
STREAM MILES
UPPER LIMIT OF STUDY
SR 42
Jct West Fork
18 SR 721 Abandoned
20 SR 721
ELEVATION (NGVD)
CHANNEL STATIONS LINVILLE CREEK
FEET ABOVE MOUTH

FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

MAM 9/80

Plate 2 of 8
See Photomap 3

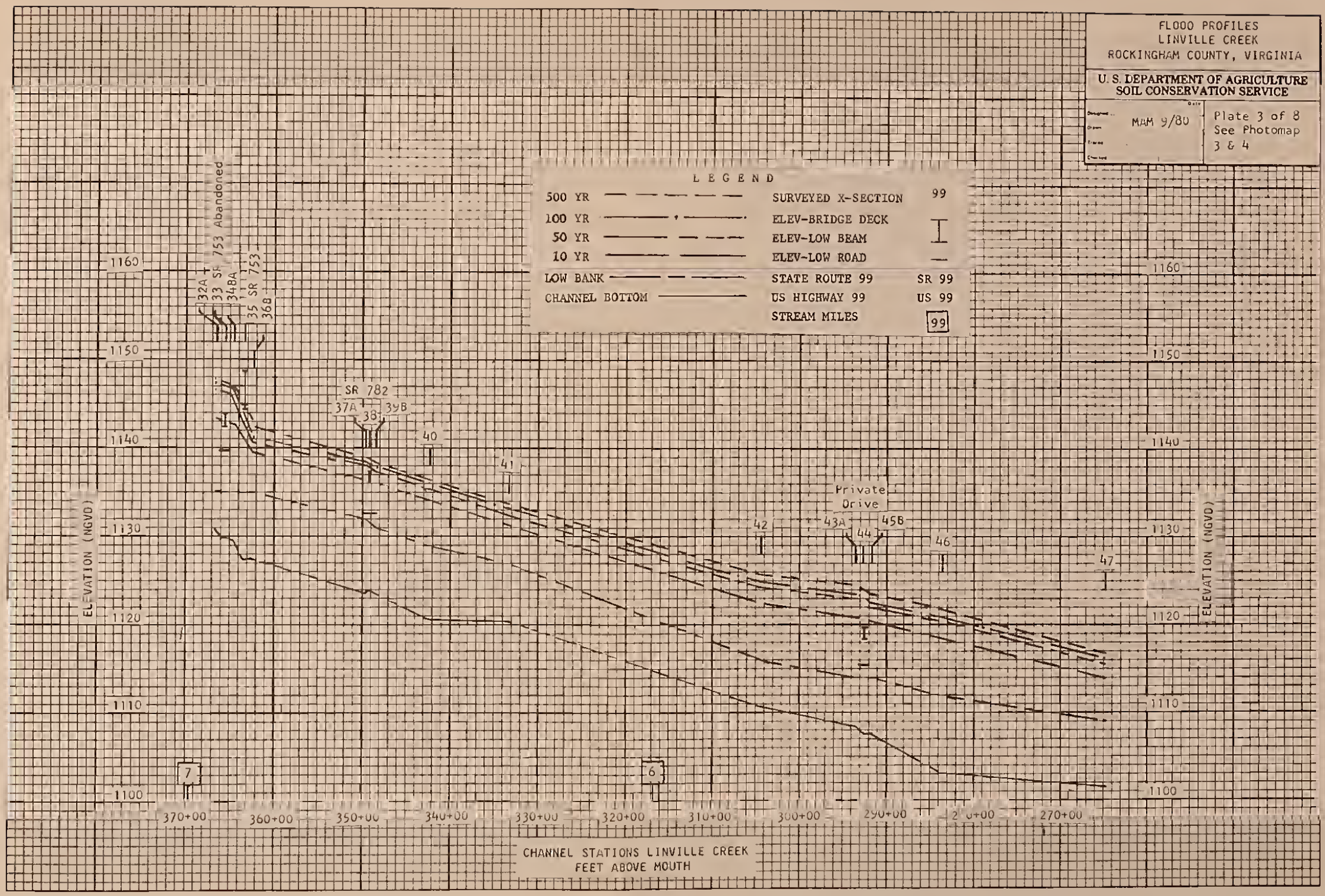


FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

MAM 9/80

Plate 3 of 8
See Photomap
3 & 4



FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

MAM 9/80

Plate 4 of 8
See Photomap
4 & 5

LEGEND

500 YR	SURVEYED X-SECTION	99
100 YR	ELEV-BRIDGE DECK	I
50 YR	ELEV-LOW BEAM	
10 YR	ELEV-LOW ROAD	—
LOW BANK	STATE ROUTE 99	SR 99
CHANNEL BOTTOM	US HIGHWAY 99	US 99
	STREAM MILES	99

47
48
49
50A
51
52B
53
54
55
SR 784
Jct. Tide
Spring

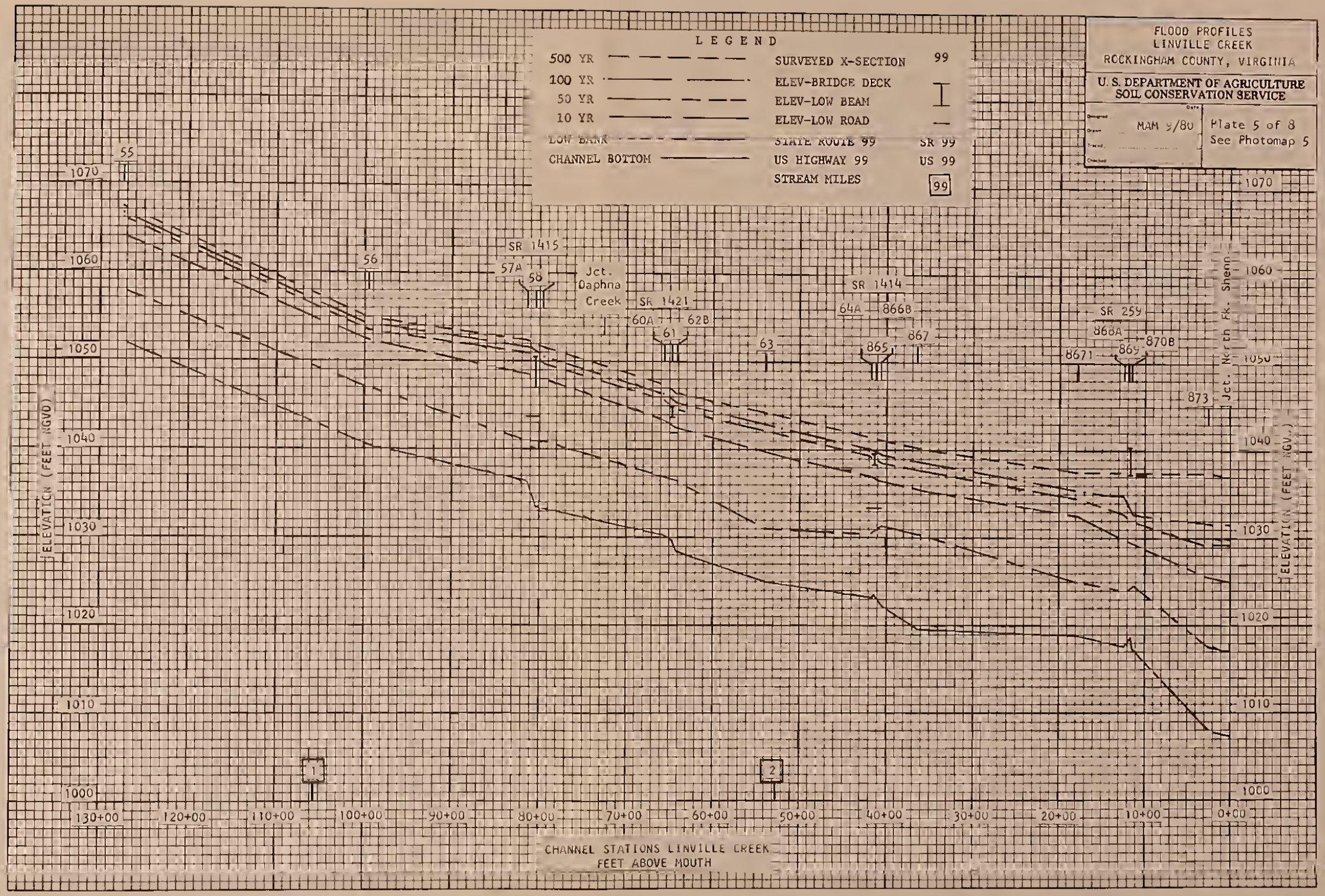
ELEVATION (FEET NGVD)

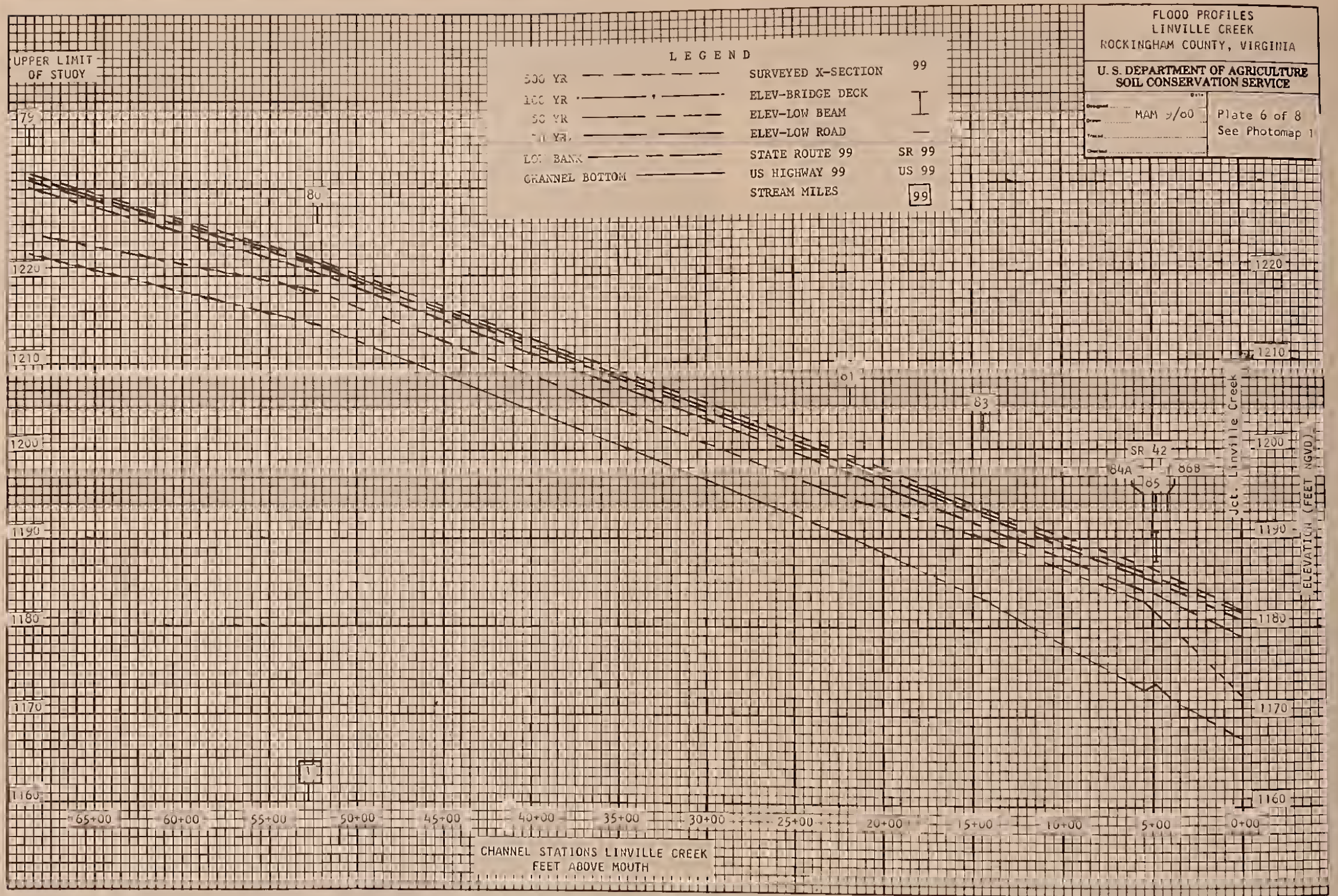
1120
1110
1100
1090
1080
1070
1060
1050

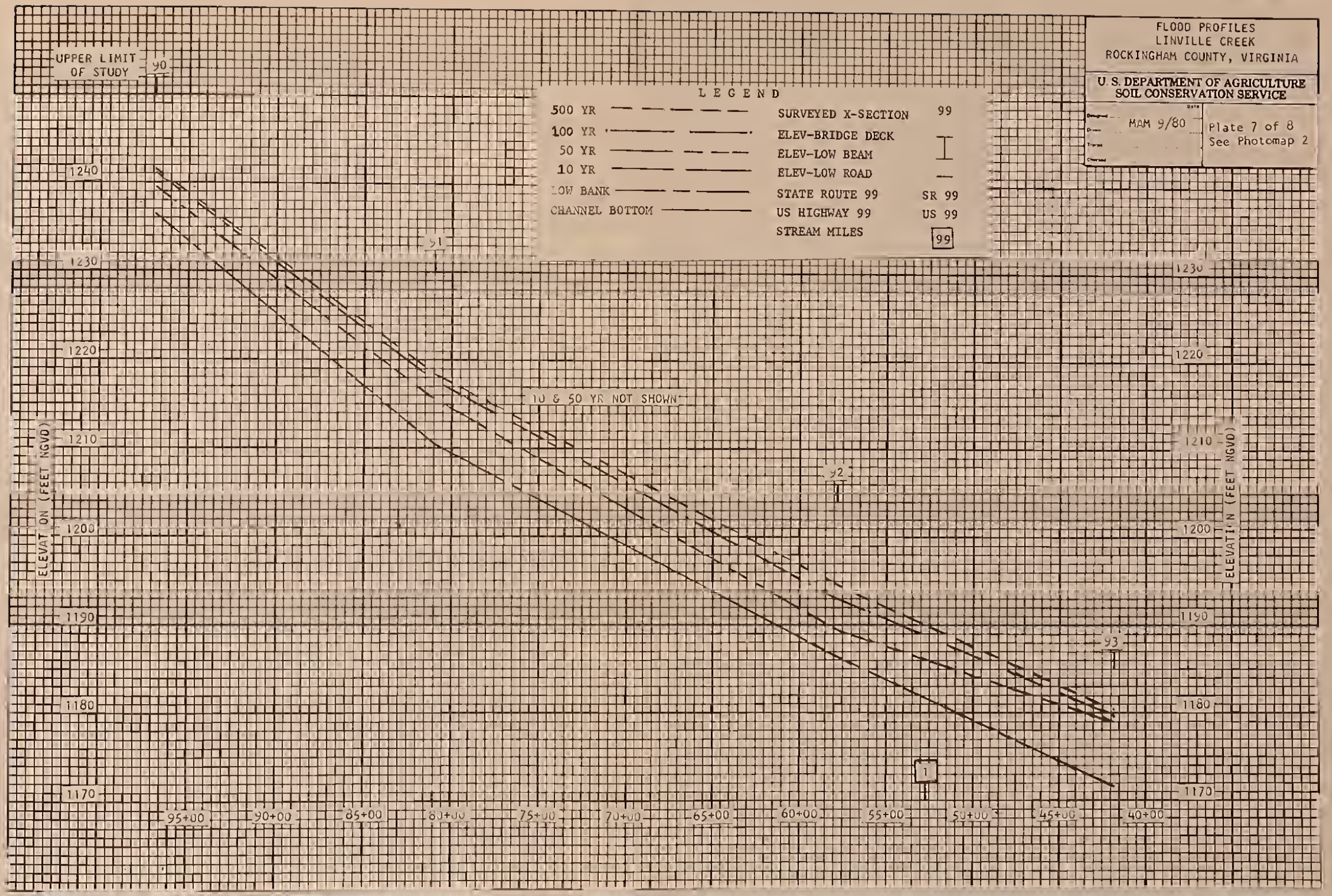
5
4
3

260+00 250+00 240+00 230+00 220+00 210+00 200+00 190+00 180+00 170+00 160+00 150+00 140+00 130+00

CHANNEL STATIONS LINVILLE CREEK
FEET ABOVE MOUTH


LEGEND
500 YR
100 YR
50 YR
10 YR
LOW BANK
CHANNEL BOTTOM
SURVEYED X-SECTION 99
ELEV-BRIDGE DECK
ELEV-LOW BEAM
ELEV-LOW ROAD
STATE ROUTE 99 SR 99
US HIGHWAY 99 US 99
STREAM MILES 99
FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MAM 9/80
Plate 5 of 8
See Photomap 5
ELEVATION (FEET NGVD)
1070
1060
1050
1040
1030
1020
1010
1000
55
56
57A
58
SR 1415
Jct. Daphna Creek
SR 1421
60A
62B
61
63
SR 1414
64A
866B
867
865
SR 259
868A
870B
869
8671
873
Jct. North Fk. Shenn
1
2
130+00
120+00
110+00
100+00
90+00
80+00
70+00
60+00
50+00
40+00
30+00
20+00
10+00
0+00
CHANNEL STATIONS LINVILLE CREEK
FEET ABOVE MOUTH


FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MAM 9/00
Plate 6 of 8
See Photomap 1
LEGEND
500 YR
100 YR
50 YR
10 YR
LOT BANK
CHANNEL BOTTOM
SURVEYED X-SECTION 99
ELEV-BRIDGE DECK
ELEV-LOW BEAM
ELEV-LOW ROAD
STATE ROUTE 99 SR 99
US HIGHWAY 99 US 99
STREAM MILES 99
UPPER LIMIT OF STUDY
79
80
81
83
84A
84B
85
SR 42
Jct. Linville Creek
1
1220
1210
1200
1190
1180
1170
1160
ELEVATION (FEET NGVD)
65+00
60+00
55+00
50+00
45+00
40+00
35+00
30+00
25+00
20+00
15+00
10+00
5+00
0+00
CHANNEL STATIONS LINVILLE CREEK
FEET ABOVE MOUTH


FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
MAM 9/80
Plate 7 of 8
See Photomap 2
LEGEND
500 YR
100 YR
50 YR
10 YR
LOW BANK
CHANNEL BOTTOM
SURVEYED X-SECTION 99
ELEV-BRIDGE DECK
ELEV-LOW BEAM
ELEV-LOW ROAD
STATE ROUTE 99 SR 99
US HIGHWAY 99 US 99
STREAM MILES 99
UPPER LIMIT OF STUDY 90
10 & 50 YR NOT SHOWN
ELEVATION (FEET NGVD)
1240
1230
1220
1210
1200
1190
1180
1170
95+00
90+00
85+00
80+00
75+00
70+00
65+00
60+00
55+00
50+00
45+00
40+00
91
92
93
1

FLOOD PROFILES
LINVILLE CREEK
ROCKINGHAM COUNTY, VIRGINIA

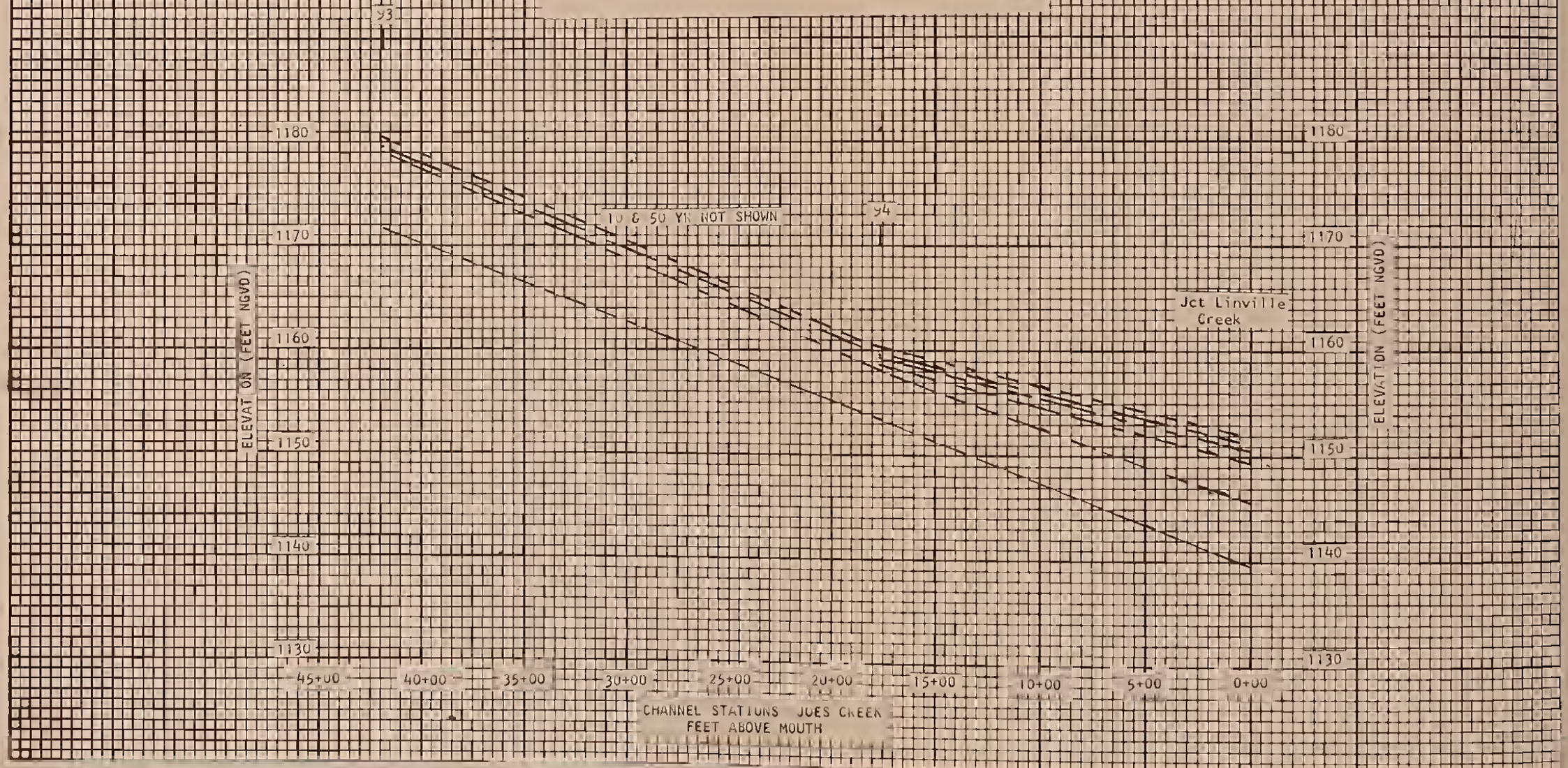
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Date: MAM 9/80

Plate 8 of 8
See Photomap 3

LEGEND

500 YR	— — — — —	SURVEYED X-SECTION	99
100 YR	——— • ———	ELEV-BRIDGE DECK	I
50 YR	——— — — ———	ELEV-LOW BEAM	I
10 YR	——— ———	ELEV-LOW ROAD	—
LOW BANK	——— — — ———	STATE ROUTE 99	SR 99
CHANNEL BOTTOM	———	US HIGHWAY 99	US 99
		STREAM MILES	99



TYPICAL CROSS SECTIONS

Linville Creek

Rockingham County, Virginia

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

	Date
Designed	
Drawn	
Traced	
Checked	

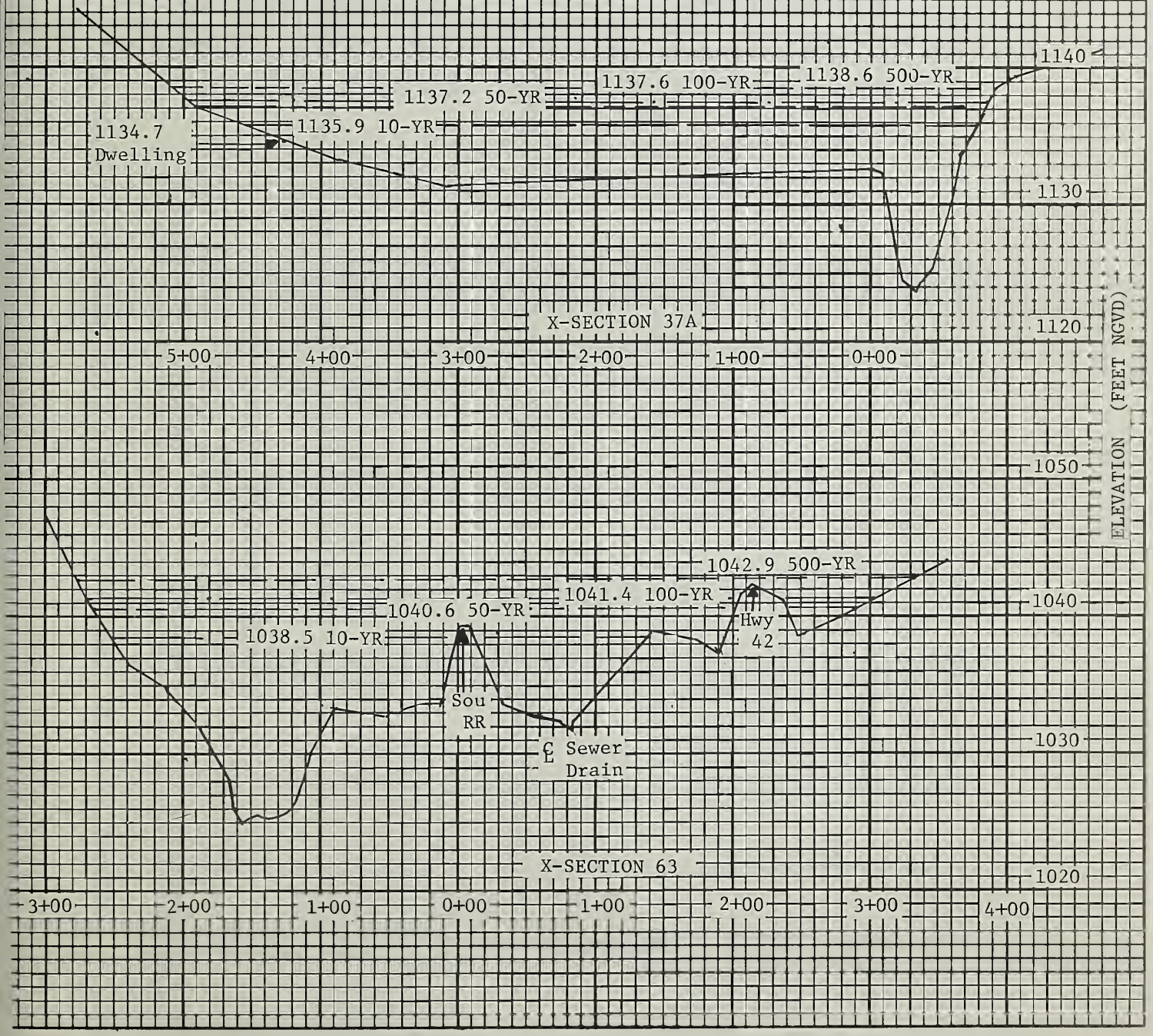


Table A-1 Frequency-discharge-elevations, Linville Creek, Rockingham County, Virginia

X-Sec.	Photo Map No.	Profile Plate No.	DA (sq mi)	10-year Disch. (cfs)	10-year Elev. (ft)	25-year Disch. (cfs)	25-year Elev. (ft)	50-year Disch. (cfs)	50-year Elev. (ft)	100-year Disch. (cfs)	100-year Elev. (ft)	500-year Disch. (cfs)	500-year Elev. (ft)
				Linville Creek upper limit of study									
10	1	1	5.17	1020	1211.6	1290	1212.2	1590	1212.7	1780	1213.1	2330	1213.9
11A	1	1	5.22	1030	1203.7	1300	1204.0	1600	1204.4	1800	1204.5	2350	1205.2
12R	1	1		State Route 42 Low Road 1211.5 Low steel 1208.7 Bridge deck 1211.5									
13B	1	1	5.74	1030	1202.4	1300	1202.8	1600	1203.3	1800	1203.5	2350	1204.0
14	1	1	6.89	1670	1198.7	2110	1199.3	2580	1199.7	2900	1200.0	3760	1200.7
15	1	1	7.46	1950	1192.4	2450	1193.2	2970	1193.8	3330	1194.1	4320	1195.0
16	1	1	7.75	2100	1181.2	2600	1182.0	3170	1182.8	3530	1183.2	4550	1183.7
17A	1	1	17.13	3980	1177.5	5000	1178.7	6110	1179.5	6830	1179.9	8880	1180.7
18R			State Route 721 Low Road 1177 Culvert Road 1180.5										
19BA	1	1	17.14	3990	1175.5	5010	1176.4	6120	1177.0	6840	1177.2	8890	1178.2
20R	1	1	State Route 721 Low Road 1180.0 Low steel 1178.7 Bridge deck 1181.8										
21B	1	1	17.16	4000	1174.0	5020	1174.7	6130	1175.5	6850	1175.8	8900	1176.6
22	1	1&2	17.27	4020	1170.6	5030	1171.7	6150	1172.0	6880	1172.2	8930	1173.0
23	3	2	17.54	4030	1165.5	5050	1166.1	6170	1166.8	6900	1167.2	8960	1168.0
24A	3	2	21.74	5150	1160.0	6400	1160.7	7700	1161.5	8800	1162.0	11200	1162.9
25R	3	2	State Route 780 Low Road 2256.5 Low steel 1157.8 Bridge deck 1159.6										
26B	3	2	21.77	5180	1158.7	6470	1159.5	7890	1160.4	8810	1161.0	11300	1161.6
27	3	2	21.83	5200	1156.7	6490	1157.7	7900	1158.9	8820	1159.5	11420	1160.0
28A	3	2	21.90	4140	1154.7	5220	1155.7	6040	1156.5	6940	1157.3	9640	1159.2
29R	3	2	State Route 42 Low Road 1161.3 Low steel 1158.2 Bridge deck 1161.3										
30B	3	2	21.92	5200	1153.4	6490	1153.9	7900	1154.5	8820	1154.9	11420	1155.2
31	3	2	29.51	5200	1145.3	6490	1145.9	7900	1146.8	8820	1147.1	11420	1148.1
32A	3	2&3	31.16	6450	1143.2	8120	1144.7	9960	1146.6	11160	1147.2	14590	1147.7
33R	3	3	State Route 753 Low Road 1139.7 Low steel 1142.4 Bridge deck 1144.0										
34BA	3	3	31.17	6460	1142.6	8130	1144.3	9970	1146.1	11200	1146.6	14800	1147.0
35R	3	3	State Route 753 Low Road 1144.8 Low steel 1144.6 Bridge deck 1144.8										
36B	3	3	31.19	6600	1139.5	8250	1140.1	10200	1140.7	11300	1141.1	15000	1142.3
37A	3	3	31.32	6750	1136.6	8580	1137.4	10480	1138.1	11700	1138.5	15300	1139.0

Continued

Table A-1 Frequency-discharge-elevations, Linville Creek, Rockingham County, Virginia--Continued

X-Sec.	Photo Map No.	Profile Plate No.	DA (sq mi)	10-year Dish. (cfs)	10-year Elev. (ft)	25-year Dish. (cfs)	25-year Elev. (ft)	50-year Dish. (cfs)	50-year Elev. (ft)	100-year Dish. (cfs)	100-year Elev. (ft)	500-year Dish. (cfs)	500-year Elev. (ft)
38R	3	3	State Route 782 Low Road 1132.5 Low steel 1136.4 Bridge deck 1137.4										
39B	3	3	31.34	6850	1136.0	8610	1136.7	10560	1137.3	11830	1137.7	15470	1138.6
40	3	3	31.58	6900	1134.1	8650	1134.7	10600	1135.5	11900	1136.0	15600	1136.4
41	3	3	33.07	7100	1131.2	8920	1132.0	10900	1132.5	12250	1133.1	16000	1133.6
42	3	3	33.67	7150	1122.6	8990	1123.5	10960	1124.4	12300	1124.9	16100	1125.9
43A	4	3	33.86	7190	1121.0	9030	1122.1	11000	1123.0	12390	1123.5	16210	1124.6
44R	4	3	Private Road Low Road 1115.3 Low steel 1118.4 Bridge deck 1119.8										
45B	4	3	33.88	7200	1120.3	9040	1121.3	11080	1122.0	12410	1122.6	16230	1123.5
46	4	3	34.00	7300	1118.8	9200	1119.6	11200	1120.5	12500	1121.0	16400	1121.9
47	4	3&4	34.43	7400	1114.0	9300	1114.8	11400	1115.6	12700	1116.1	16700	1116.9
48	4	4	38.69	7850	1093.4	9900	1094.2	12100	1095.1	13400	1095.5	17800	1096.2
49	4	4	39.15	8000	1082.5	10000	1083.6	12200	1084.6	13500	1085.1	17950	1086.0
50A	4	4	39.18	8020	1082.2	10020	1083.4	12300	1084.3	13600	1084.7	18000	1085.6
51R	4	4	State Route 809 Low Road 1080.7 Low steel 1082.9 Bridge deck 1086.8										
52B	4	4	39.47	8060	1080.2	10120	1081.0	12390	1081.7	13880	1082.3	18170	1083.3
53	4	4	39.63	8100	1075.0	10150	1075.7	12400	1076.5	13910	1077.0	18230	1077.9
54	5	4	40.07	8150	1069.0	10180	1069.8	12420	±1070.7	03950	1071.4	18300	1072.4
55	5	4&5	41.67	8250	1064.7	10250	1065.4	12510	1066.1	14040	1066.7	18420	1067.4
56	5	5	42.21	8280	1052.5	10320	1053.1	12600	1053.6	14130	1054.2	18540	1055.0
57A	5	5	42.39	8310	1048.7	10390	1049.7	12690	1051.0	14220	1051.5	18660	1052.6
58R	5	5	State Route 1415 Low Road 1043.8 Low steel 1047.0 Bridge deck 1050.3										
59B	5	5	42.40	8340	1048.0	10450	1049.1	12790	1049.9	14320	1050.5	18770	1051.5
60A	5	5	47.00	9000	1043.5	11330	1044.8	13600	1045.9	15500	1046.5	20500	1047.6
61R	5	5	State Route 1421 Low Road 1042.0 Low steel 1043.9 Bridge deck 1045.0										
62B	5	5	47.00	9000	1042.6	11330	1043.6	13600	1044.5	15500	1045.2	20500	1046.3
63	5	5	47.20	9010	1039.9	11340	1041.2	13610	1042.1	15510	1042.7	20510	1044.1
64A	5	5	47.20	9010	0137.1	11340	1038.3	13610	1039.3	15510	1040.0	20510	1041.5
865R	13 on N-FK	5	State Route 1414 Low Road 1033.30 Low steel 1038.5 Bridge deck 1038.9										
866B	13	5	47.22	9020	1036.5	11350	1037.6	13620	1038.6	15520	1039.4	20510	1040.8
867	13	5	47.27	9050	1035.6	11370	1036.8	13730	1037.9	15560	1038.6	20520	1040.1

Continued

Table A-1 Frequency-discharge-elevations, Linville Creek, Rockingham County, Virginia

X-Sec.	Photo Map No.	Profile Plate No.	DA (sq mi)	10-year Dish (cfs)	10-year Elev. (ft)	25-year Dish. (cfs)	25-year Elev. (ft)	50-year Dish. (cfs)	50-year Elev. (ft)	100-year Dish. (cfs)	100-year Elev. (ft)	500-year Dish. (cfs)	500-year Elev. (ft)
8671	13	5	47.87	9080	1032.5	11390	1033.4	13830	1034.6	15600	1035.4	20520	1037.6
868A	13	5	47.97	9110	0129.9	11410	1031.4	13930	1032.9	15640	1034.9	20520	1037.5*
869R	13	5	State Route 259 Low Road 1037.4 Low steel 1037.5 Bridge deck 1040.4										
870B	13	5	47.97	9130	1029.3	11430	1030.7	13970	1032.0	15640	1032.7	20530	1037.4*
873	13	5	48.00	9130	1025.6	11430	1027.5	13970	1029.1	*15660	1031.7	*20530	1037.4*
Jct W/N-FK			Sections 865R through 873 are sections through the town of Broadway from the North Fork Shenandoah River study (Reference 11). The elevations and discharges were recomputed even through this area is outside the limits of the Linville Creek Study. *Back water from North Fork will cause higher elevations on the 3 lower x-sections on Linville Creek than normally would be. (The 100 yr & 500 yr only.) (Except for x-section 873 which is only 300 feet up str from Jct.)										
			West Fork tributary - upper limit of study										
79	1	6	7.14	1920	1230.1	2400	1230.5	2950	1231.0	3300	1231.3	4310	1231.7
80	1	6	7.30	1950	1220.5	2440	1221.0	2990	1221.2	3350	1221.4	4350	1221.6
81	1	6	7.80	1990	1197.3	2500	1197.7	3050	1198.4	3410	1198.6	4450	1199.5
83	1	6	7.90	2000	1191.1	2510	1191.8	3070	1192.4	3440	1192.7	4480	1193.4
84A	1	6	7.90	2000	1184.2	2510	1185.1	3070	1185.8	3440	1186.2	4480	1187.1
85R	1	6	State Route 42 Low Road 1188.0 Low steel 1187.6 Bridge deck 1190.8										
86B	1	6	7.90	2000	1183.1	2510	1184.0	3070	1184.5	3440	1185.0	4480	1185.9
Jct. w/Linville Crk			7.90		1179.0		1180.3		1180.8		1181.6		1182.0
			Joes Creek tributary - upper limit of study										
Top w/s													
JC 90	2	7	6.03	1090	1240.5	1430	1240.7	1820	1240.9	2070	1241.1	2800	1241.5
JC 91	2	7	6.40	1120	1216.9	1480	1217.2	1890	1217.5	2150	1217.7	2900	1218.2
JC 92	2	7	7.10	1210	1192.2	1580	1192.5	2020	1192.9	2290	1193.2	3090	1194.8
JC 94	3	8	7.40	1250	1158.7	1630	1159.0	2060	1159.4	2350	1159.6	3170	1160.2
Jct. w/Linville Crk					1149.4		1150.0		1150.7		1151.1		1151.9

Table A-2 Benchmark descriptions, Linville Creek, Rockingham County, Virginia - 1979

BM No.	Photo Sheet No.	Description, Location and Elevation
40	1	SCS TBM - A square is chiseled on the downstream abutment (east end) of concrete bridge over Linville Creek on State Route 42, approx. 150 feet north of Ralph Miller farm road and 150' south of junction of State Route 772 and 42. Elevation 1211.89.
46	1	SCS TBM - A square is chiseled on the upstream (northwest) corner of concrete bridge over Linville Creek on State Route 721 near Edom. Elevation 1184.15.
52	3	SCS TBM - A square is chiseled on the upstream (west end) abutment of concrete bridge over Linville Creek, 175' west of junction with State Route 42 and State Route 753. Elevation 1157.66.
90	2	SCS TBM - At base of concrete post on straw shed, seventy-one feet north of low water bridge on Joe's Creek and approx. 100 feet north of junction of State Route 910 and State Route 780. Elevation 1280.30.
61	4	SCS TBM - A square is chiseled on the upstream (southeast) corner of bridge over Linville Creek leading to Sam Shank property. Elevation 1119.49.
16A	4	SCS TBM - A square is chiseled on the upstream (southeast) corner of old abutment above new bridge over Linville Creek. Elevation 1078.40.
14	5	SCS TBM - A square is chiseled on the downstream (north) abutment of bridge over Linville Creek on State Route 1415. Elevation 1049.92.

Elevations are referenced to the National Geodetic Vertical Datum 1929.

TECHNICAL PROCEDURES

Approximately 65 cross sections and 14 miles of profile levels were surveyed for this study. Surveys are referenced to National Geodetic Vertical Datum (NGVD) of 1929. Elevation reference marks (BM) are listed in Table A-2 and shown on appropriate photomaps.

The peak discharge-frequency relations of stream gages in the vicinity were determined by the USGS office in Richmond, Virginia, using a log-Pearson Type III analysis (per Water Resources Council Bulletin 17A, reference 8). These discharges were correlated with TR 20 routings (reference 9) within the watersheds and used to determine peak discharge-frequency relations for the surveyed cross sections. The resultant data agrees with observed high water marks along Linville Creek.

Analyses of the hydraulic characteristics of streams were carried out using the SCS computer program WSP-2 (Reference 10). Cross section data for the streams and structural geometry of bridges and culverts were obtained by transit surveys. From stage-discharge curves, elevations and flood boundaries could be determined at the cross sections. Straight line interpolations of the elevations were used for flood profiles between cross sections. Flood boundaries between cross sections were drawn on topographic maps using contour lines as a guide. These lines were transposed to the photomaps and checked in the field. Discharges, elevations, and flood boundaries were compared with the results of a previous study (Reference 11).

Glossary of Terms

backwater. High water caused by downstream obstruction or restriction, or by high stage on an intersecting stream.

BM. Benchmark of established elevation.

cfs. Cubic feet per second - a unit of discharge that is equal to the flow of one cubic foot per second past a given point.

cross section. Shape and dimensions of a channel and valley perpendicular to the line of flow.

elev.-bridge deck. Elevation of a roadway across a bridge or culvert.

elev.-low beam. Elevation of lowest structural "beam" that limits the height of the bridge opening; or may indicate the top of a culvert opening.

elev.-low road. Elevation of low point on a roadway approaching or crossing a bridge or culvert - shown only if lower than elev.-bridge deck at a particular road section.

flood. An overflow of lands not normally covered by water; a temporary increase in streamflow or stage; or the discharge causing the overflow or temporary increase.

flood frequency. An expression of how often a flood of given magnitude can be expected.
10-year frequency flood. The flood which can be expected or exceeded on an average once in 10 years; or which would have a 10 percent chance of being equalled or exceeded in any given year. 100-year frequency flood. ....one percent chance....in any given year.

flood peak or peak discharge. Highest discharge attained during a flood.

flood plain or flood-prone area. Lands adjoining a stream (or other body of water) which has been or may be covered with water.

flood profile or profile. A plotted or imaginary line defining the highest water surface elevations along a stream during a particular flood.

flood-prone area. See flood plain.

flood routing. Computation of the changes in the rise and fall in streamflow as a flood moves downstream. The results provide hydrographs of discharge versus time at given points on the stream.

floodway. The portion of the stream channel and flood plain that must be kept free of encroachment to prevent flood stages more than 1 foot higher than natural conditions.

frequency-discharge curve. A plotted line showing the recurrence interval (or flood frequency) of discharges at a stream gage, surveyed cross section, or other station along stream. (Used with a stage-discharge curve to determine the high water elevations resulting from selected flood discharges at that station on the stream.)

hydrograph. A curve showing the rise and fall of flood discharge with respect to time at a specific station on the stream.

land use. Classification of type of vegetation or other surface cover conditions on a watershed - used (with a similar classification of soils) to indicate the rate and volume of flood runoff.

NGVD. National Geodetic Vertical Datum of 1929.

peak discharge or flood peak. The highest rage of runoff (discharge) attained during a flood.

profile. See flood profile.

runoff. That portion of the total storm rainfall flowing across the ground or other surface and contributing to the flood discharge.

stage-discharge curve. A plotted curve showing elevations resulting from a range of discharges at a surveyed cross section, stream gage, or other point on a stream.

TBM. Temporary benchmark.

watershed. A drainage area which collects and transmits runoff to the outlet of the drainage basin.

REFERENCES CITED

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4. A Unified National Program for Flood Plain Management, U. S. Water Resources Council, Washington, D. C., July 1976.

5. Regulation of Flood Hazard Areas to Reduce Flood Losses, (two volumes), U. S. Water Resources Council, Washington, D. C., 1971 and 1972.

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10. WSP2 Computer Program, Soil Conservation Service Technical Release No. 61, May 1976.

11. Flood Hazard Analyses, North Fork Shenandoah River and Tributaries, Soil Conservation Service, Richmond, Va., February 1977.